EXPERIMENTAL OPPORTUNITIES AT 12 GeV

ED KINNEY

13 JANUARY 2000

- INTRODUCTION
- OVERVIEW
- A PLUG FOR HIGH x MEASUREMENTS
- WHAT IS MISSING ?
- WILD SPECULATION

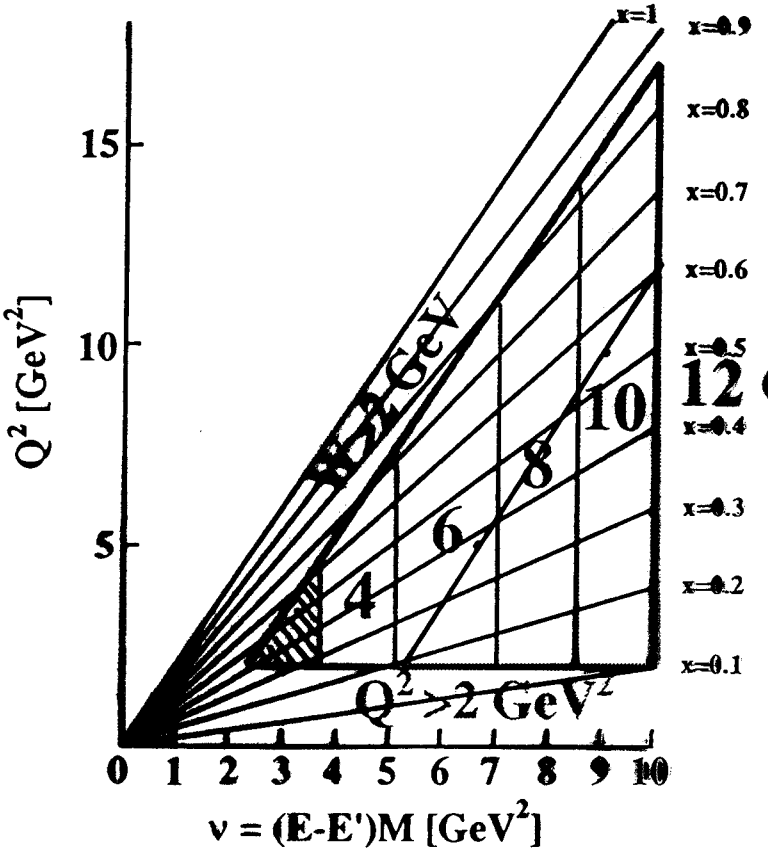
QUESTIONS

- MASS AND BINDING OF HADRONS
- CONSTITUENT VS CURRENT QUARKS
- INTERACTIONS OF HADRONS
- GIVEN $\mathcal{L}_{QCD}$, WHY DO THINGS "SEEM" SIMPLE

Overview of Working Groups

- Exclusive Reactions & Skewed Parton Distributions
  DVCS, RCS, $(e,e'\pi)$, $d(\gamma,p)n$ ...
  + Form Factors of Hadrons
- Hadrons in the Nuclear Medium
  Color Transpadency $(e,e'p)$
  $x > 1$
  Nuclear Effects in DIS
- Threshold Charm Production
  J/ψ and Open Charm
- Quark - Hadron Duality
  Connecting Resonance Region & DIS
  Inclusive → Semi-inclusive ?
- Valence Quark Structure
  Nucleon Structure at High x
  Use Low Q^2 to look for Higher Twist

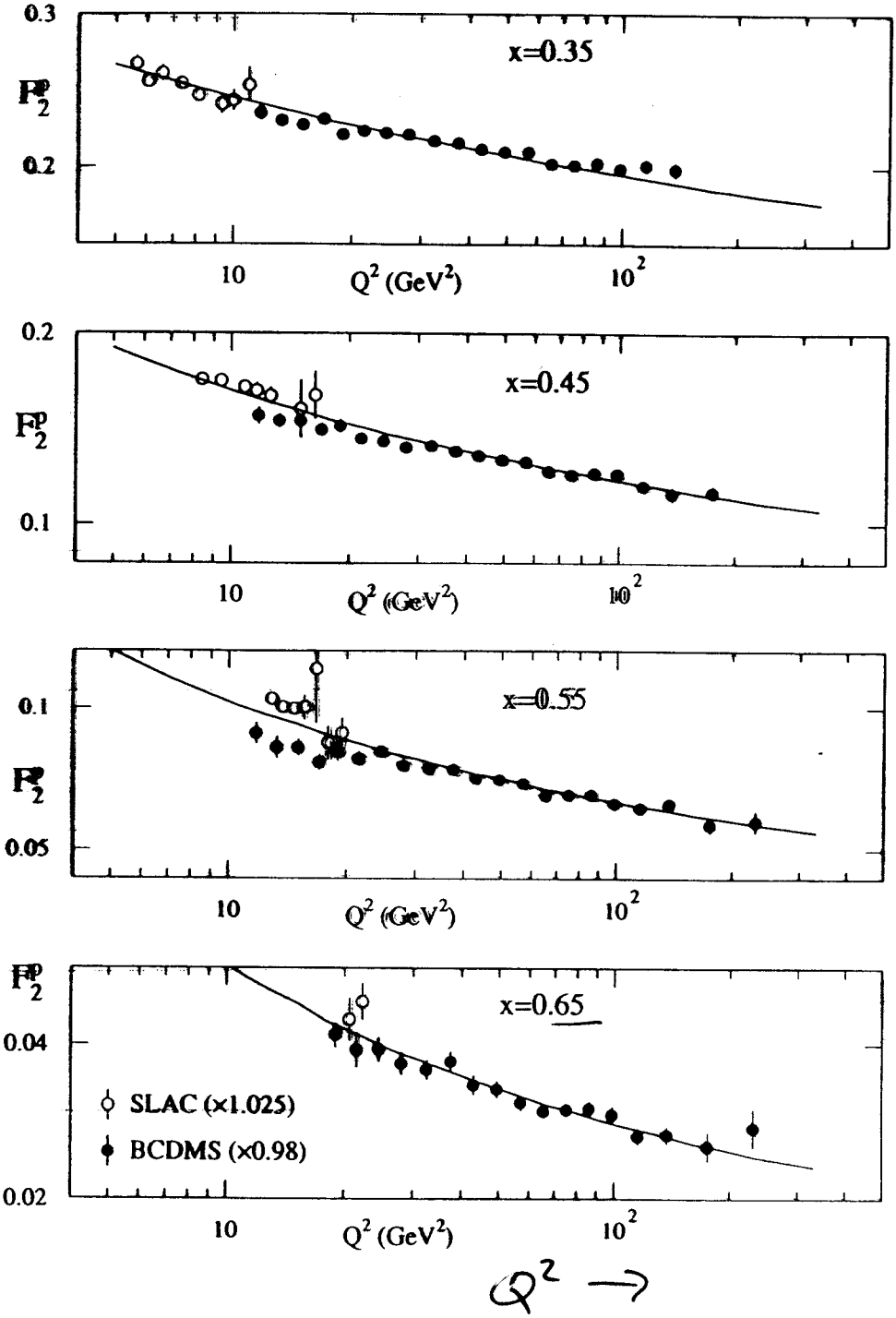
KINEMATIC RANGE



W > 3 GeV

FROM L. CARDMAN

1998 WORKSHOP PROC.



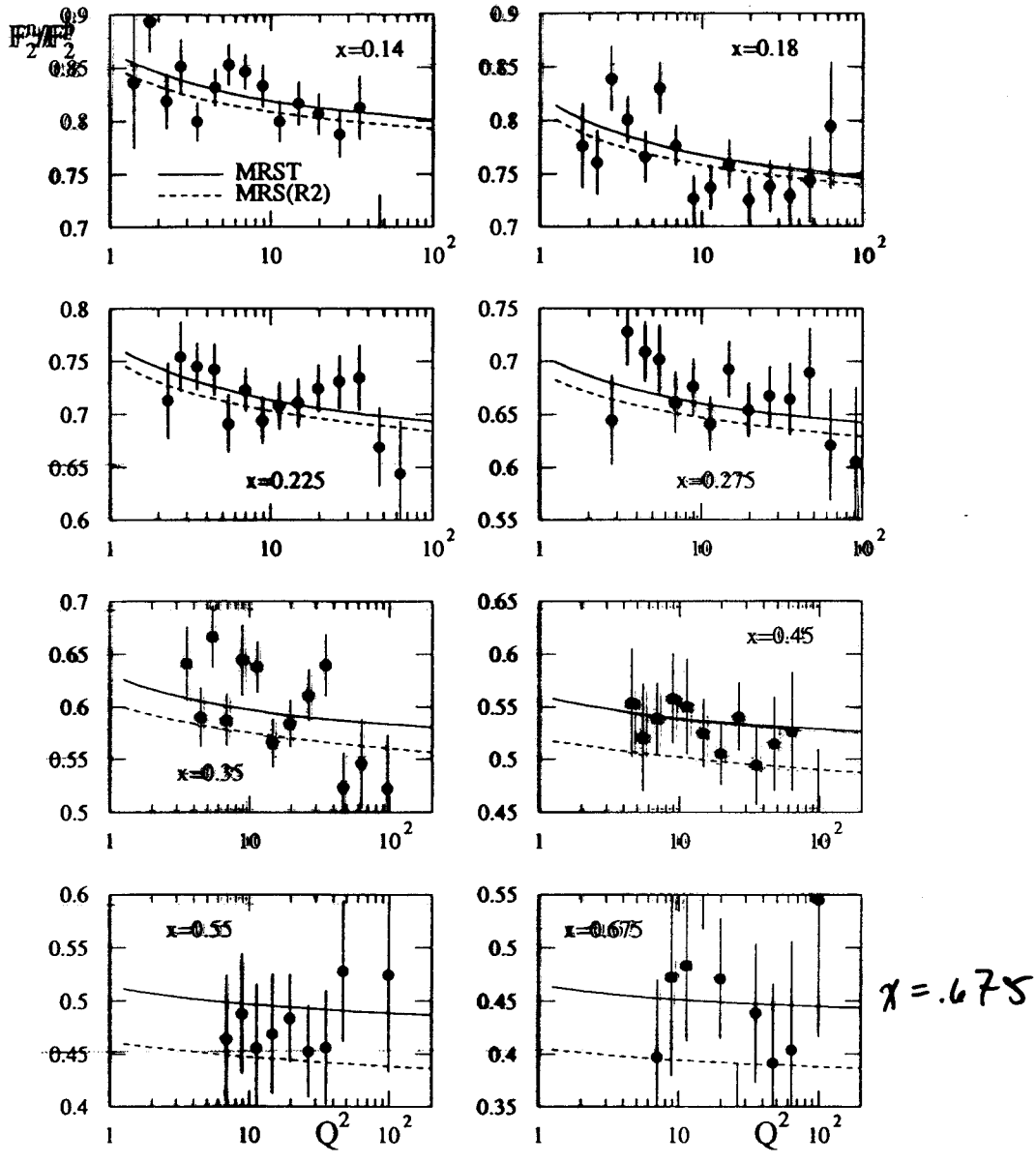
Λ^2

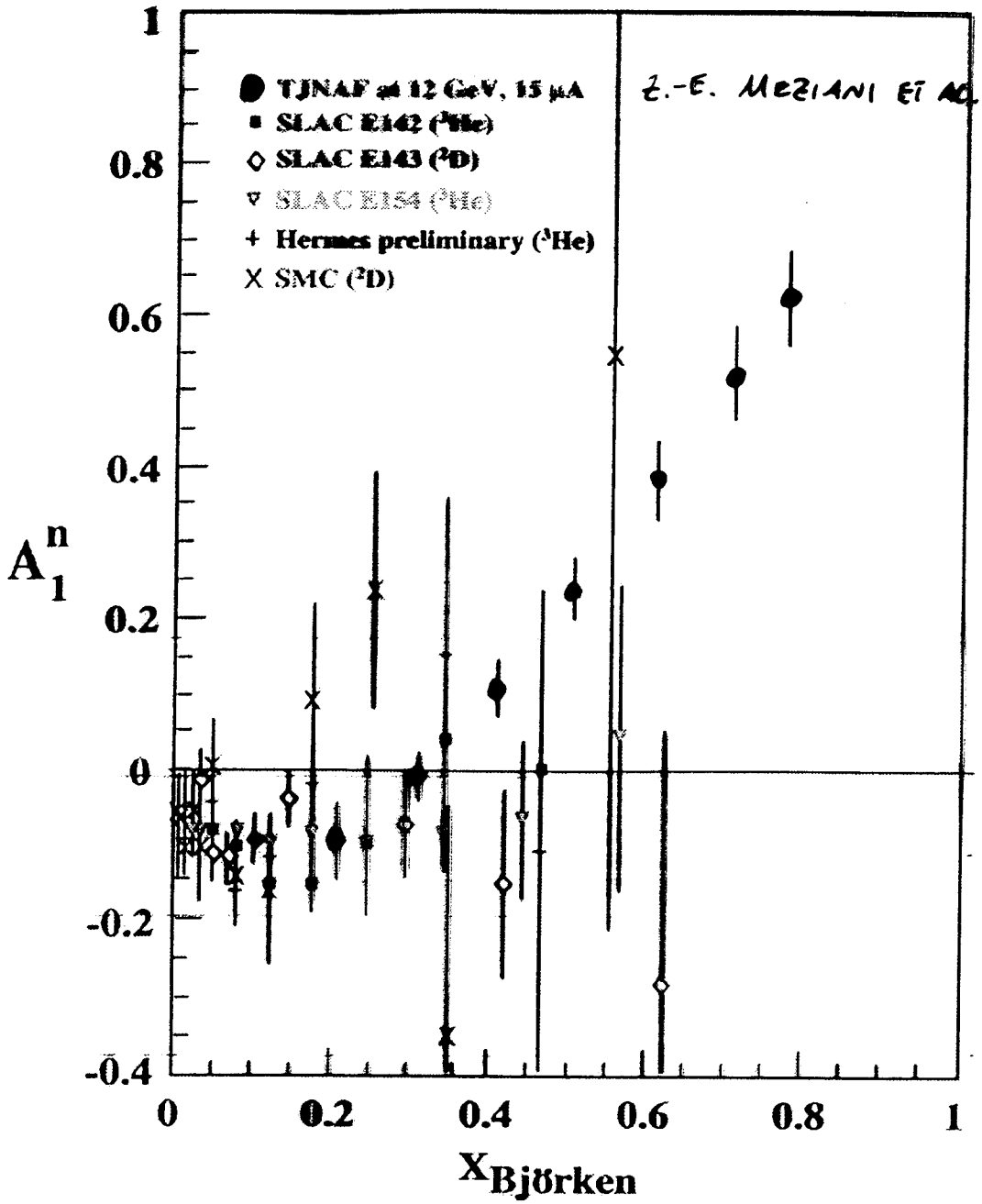
$Q^2 \rightarrow$

From MARTIN, Roberts, Stirling, Thorne

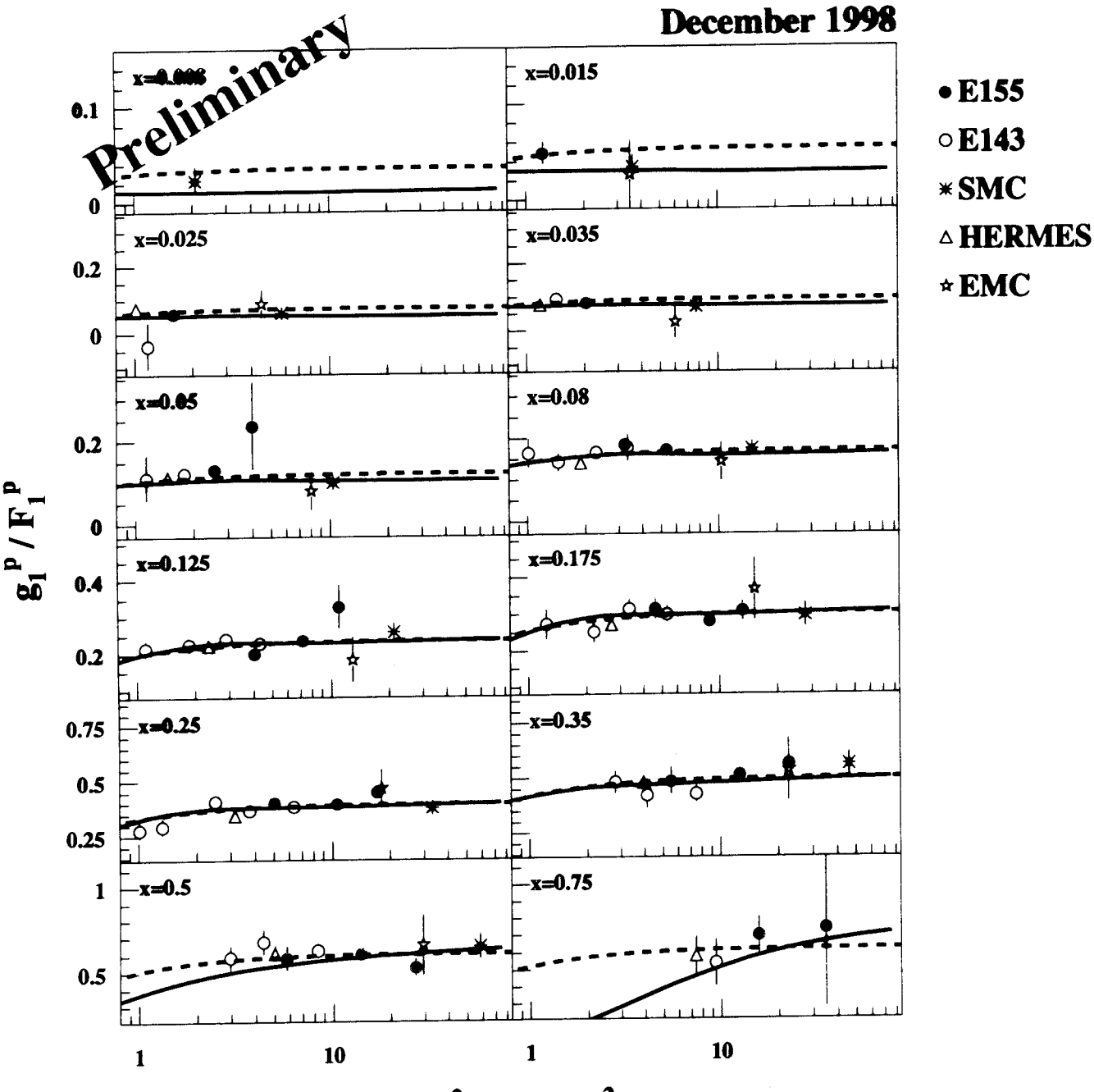
Eur. Phys J CH

p. 463 (1998).

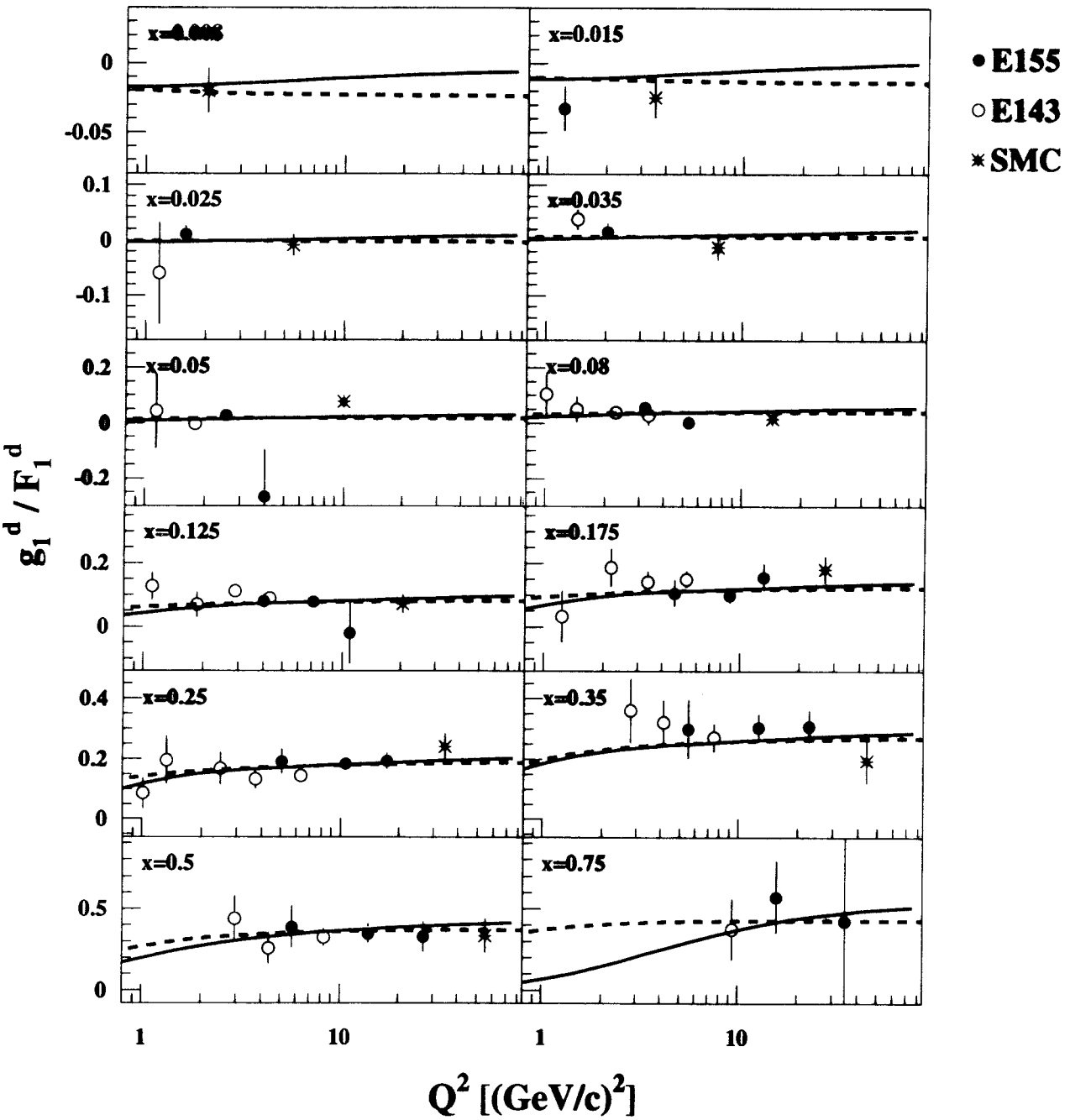

F_2^n/F_2^p
x=0.14
x=0.18
MRST
MRS(R2)
x=0.225
x=0.275
x=0.35
x=0.45
x=0.55
x=0.675
Q^2
$x = .675$
$\rightarrow Q^2$



PROPOSED ^3He MEASUREMENT


December 1998
Preliminary
x=0.015
x=0.025
x=0.035
x=0.05
x=0.08
x=0.125
x=0.175
x=0.25
x=0.35
x=0.5
x=0.75
E155
E143
SMC
HERMES
EMC
g_1^p / F_1^p
Q^2 [(GeV/c)^2]

FROM E155


x=0.006
x=0.015
x=0.025
x=0.035
x=0.05
x=0.08
x=0.125
x=0.175
x=0.25
x=0.35
x=0.5
x=0.75
E155
E143
SMC
g_1^d / F_1^d
Q^2 [(GeV/c)^2]

- High x STRUCTURE IS IMPORTANT!

  → TEST QCD SUM RULES

  → THROUGH NLO Q^2 EVOLUTION

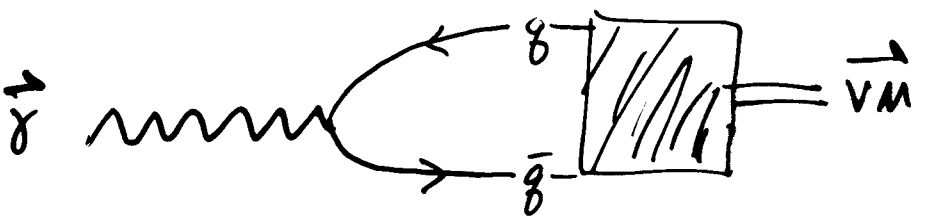
  THE DATA HAVE A LARGE IMPACT

- SEMI-INCLUSIVE AT HIGH x

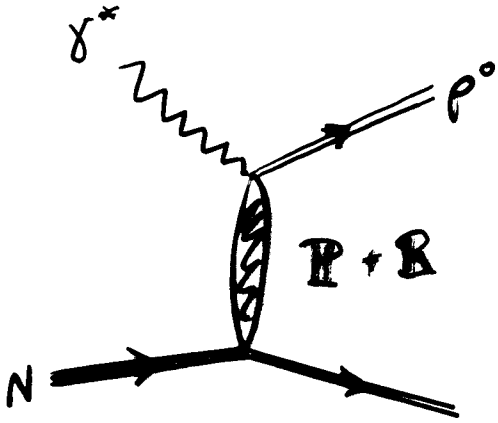
What is "MISSING" FROM "THE PROGRAM"?

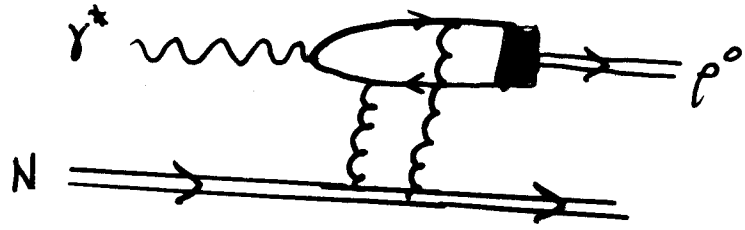
→ ATTEMPTS TO MEASURE

$\gamma \to VM$ HELICITY AMPLITUDES

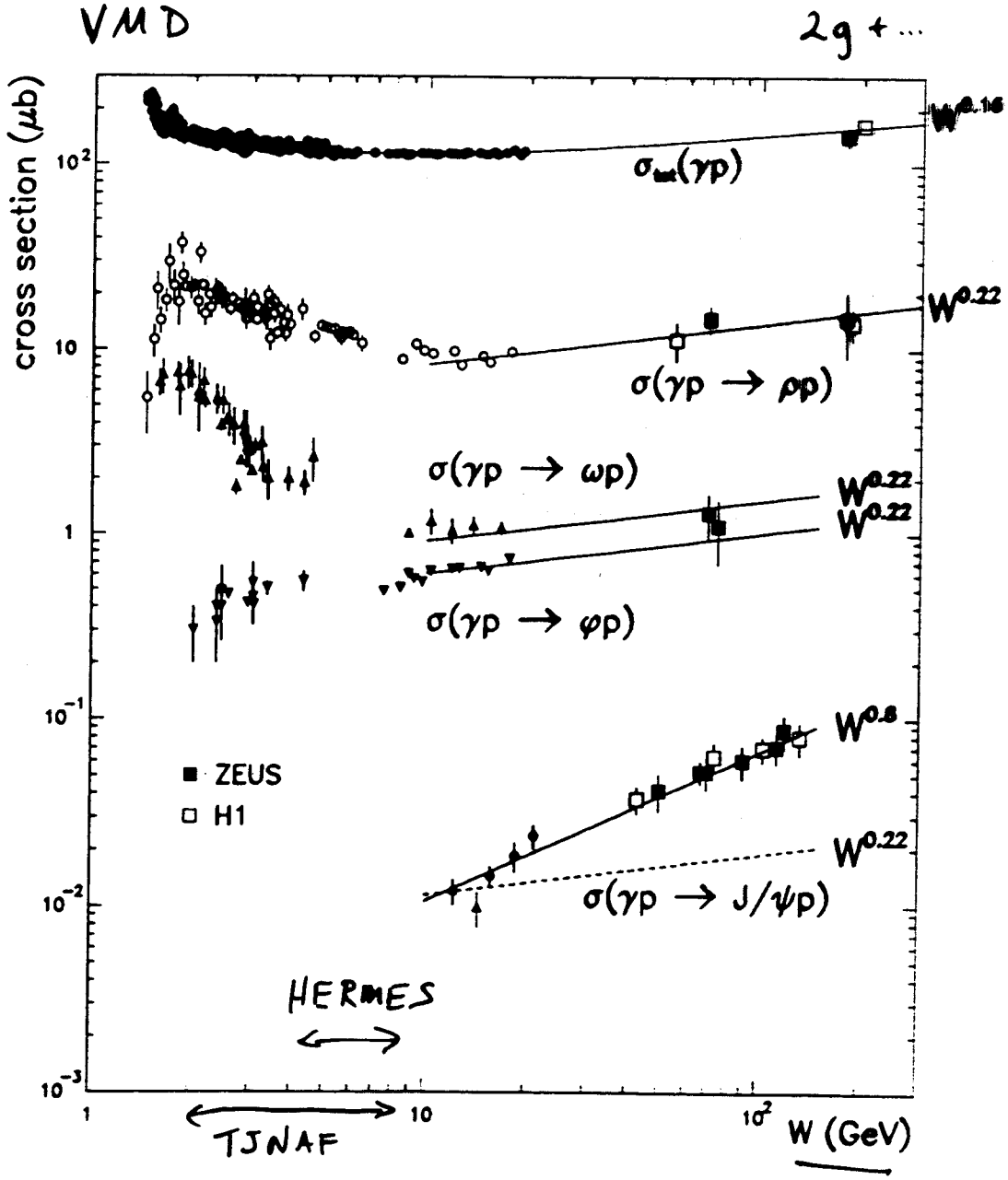


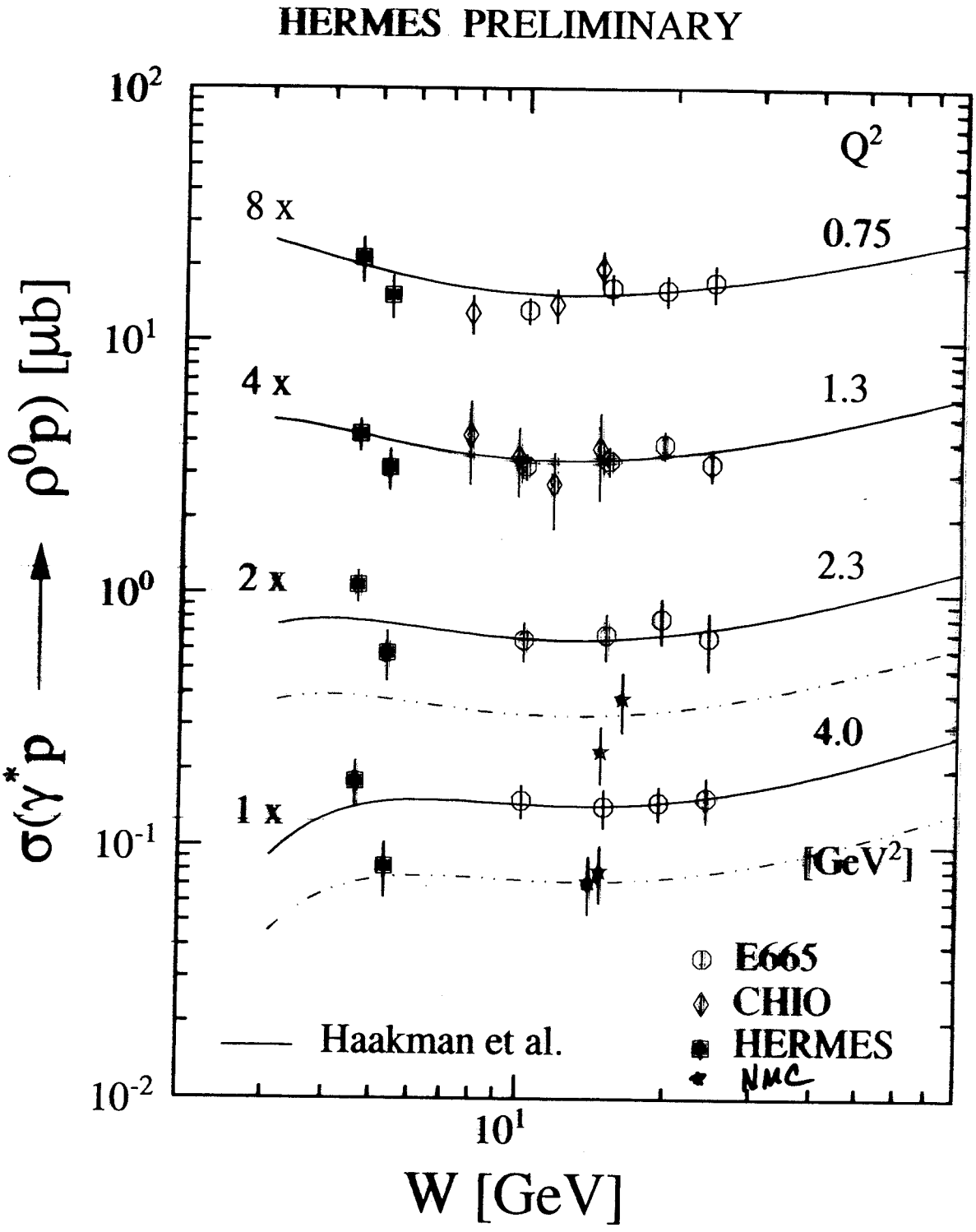
BUT 1st ...

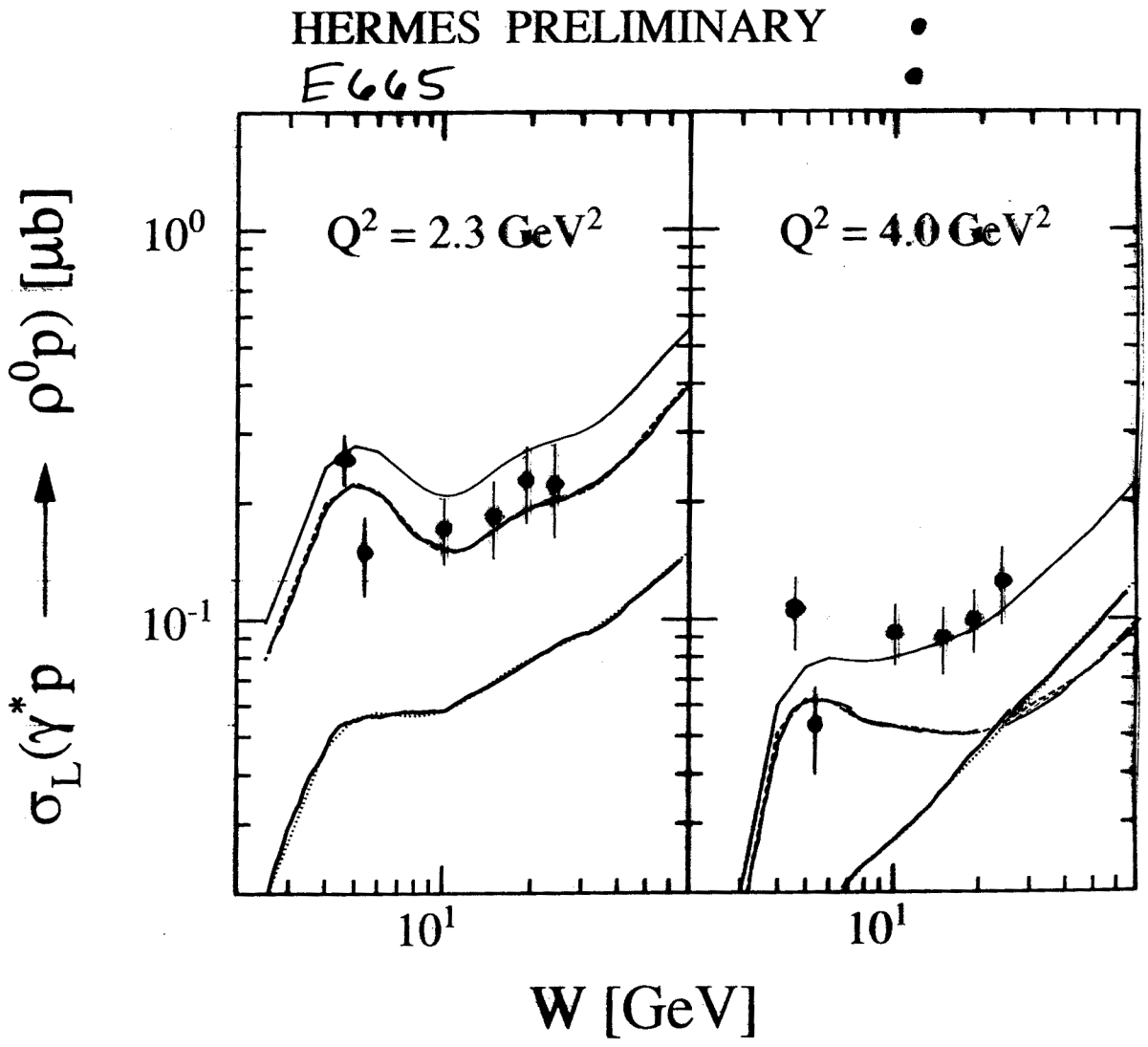




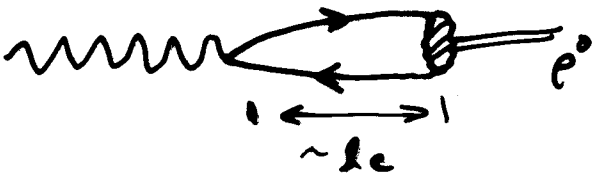
VECTOR MESON PHOTOPRODUCTION



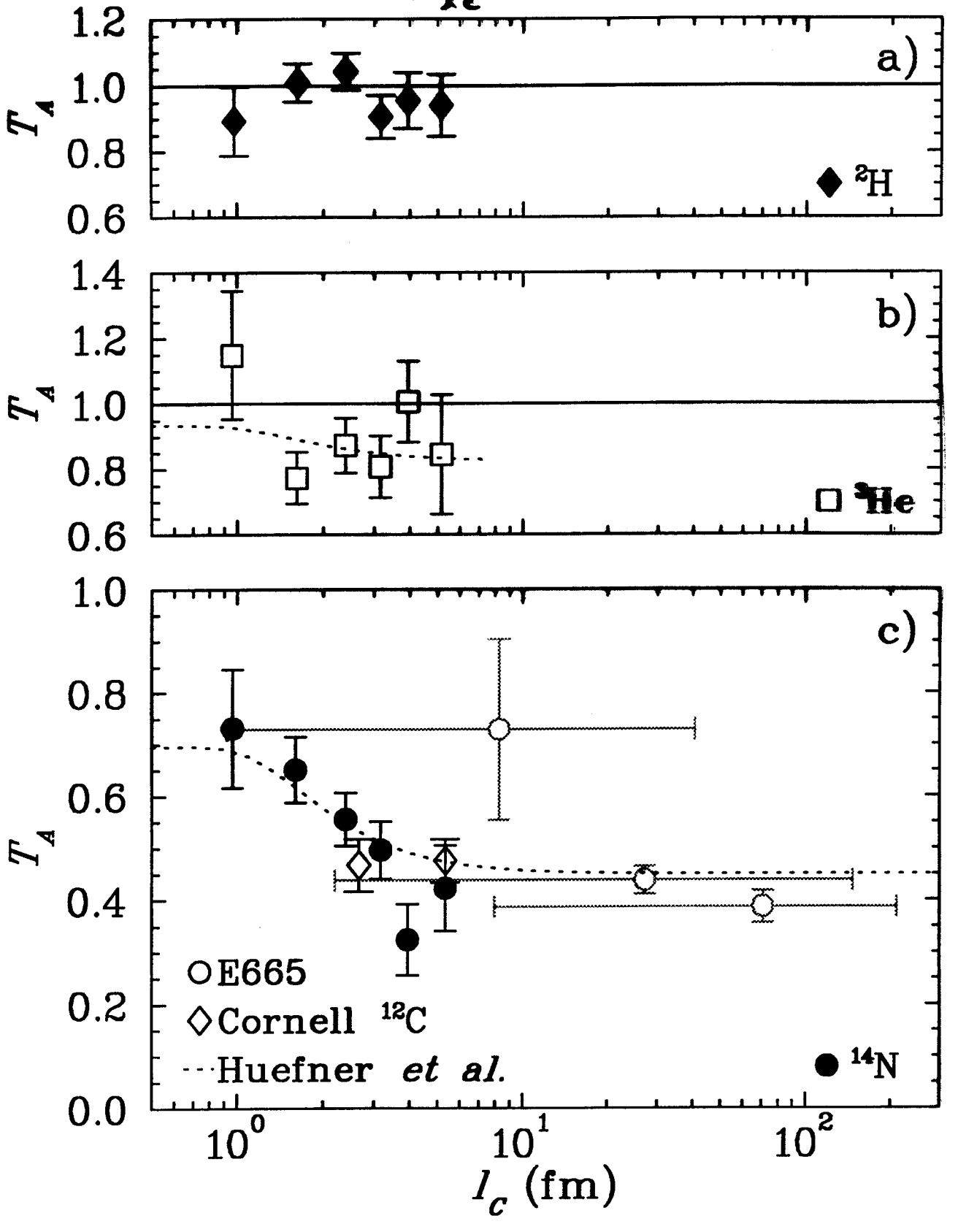

HERMES PRELIMINARY
10^2
10^1
10^0
10^{-1}
10^{-2}
$\sigma(\gamma^* p \rightarrow \rho^0 p)$ [μb]
Q^2
8 x
0.75
4 x
1.3
2 x
2.3
4.0
1 x
[GeV^2]
E665
CHIO
HERMES
NMC
Haakman et al.
10^1
W [GeV]


HERMES PRELIMINARY
E665
$Q^2 = 2.3\ \mathrm{GeV}^2$
$Q^2 = 4.0\ \mathrm{GeV}^2$
10^0
10^{-1}
10^1
10^1
$\sigma_L(\gamma^* p \longrightarrow \rho^0 p)$ [μb]
W [GeV]
QUARK EXCHANGE
2 gluon
Vanderhaeghen,
Guichon,
&
Guidal

ρ^0 ELECTRO PRODUCTION

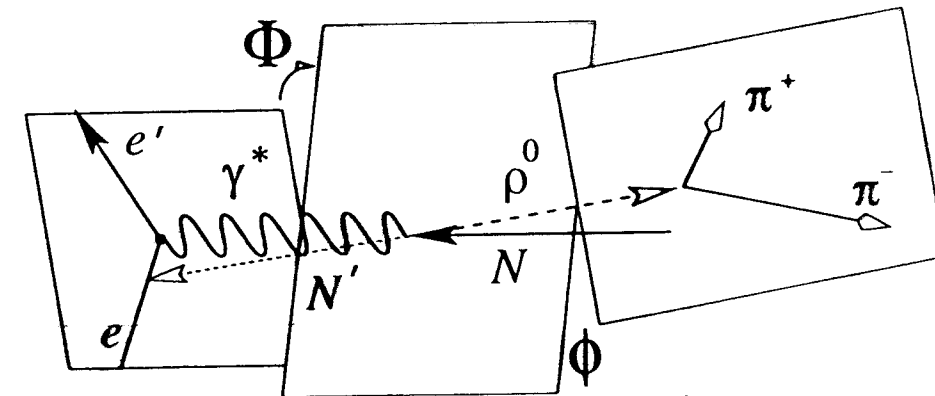


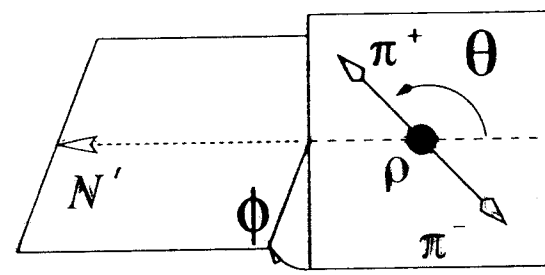
$$l_c \sim \frac{2\nu}{Q^2 + M^2_{q\bar{q}}}$$



DECAY ANGLES

Photon-Nucleon CMS





ρ^0 Rest Frame

Formal Decay Distribution

(Schilling & Wolf)

$$W(\cos\theta, \phi, \Phi) \propto \sum_{\lambda\lambda'} D^1_{\lambda 0}(\theta,\phi)^* \rho_{\lambda,\lambda'}(\Phi) D^1_{\lambda' 0}(\theta,\phi)$$

where $\rho_{\lambda\lambda'} = \frac{1}{2} T_{\lambda\gamma} \Gamma_{\gamma\gamma'}(\Phi) T^*_{\lambda',\gamma'}$

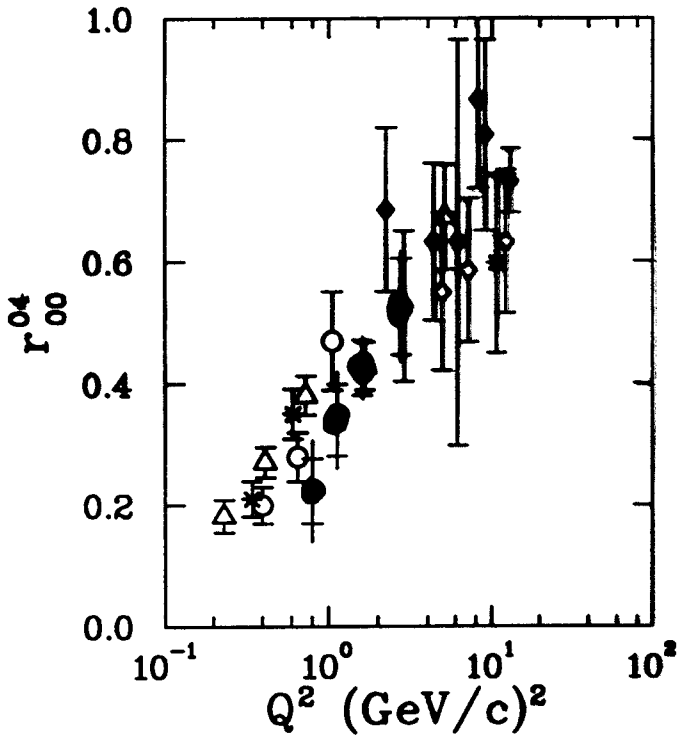
- $\rho_{\lambda\lambda'}$: spin density of ρ^0
- $\Gamma_{\gamma\gamma'}$: T/L photon flux
- $T^*_{\lambda',\gamma'}$: γ^*-VM coupling

$$\begin{aligned}
W(\cos\theta,\phi,\Phi) &= \frac{3}{4\pi}\Big(\frac{1}{2}(1-r^{04}_{00}) + \frac{1}{2}(3r^{04}_{00}-1)\cos^2\theta \\
&-\sqrt{2}\Re r^{04}_{10}\sin 2\theta\cos\phi - r^{04}_{1-1}\sin^2\theta\cos 2\phi \\
&-\epsilon\cos 2\Phi\left(r^1_{11}\sin^2\theta + r^1_{00}\cos^2 - \sqrt{2}\Re r^1_{10}\sin 2\theta\cos\phi - r^1_{1-1}\sin^2\theta\cos 2\phi\right) \\
&-\epsilon\sin 2\Phi\left(\sqrt{2}\Im r^2_{10}\sin^2\theta\sin\phi + \Im r^2_{1-1}\sin^2\theta\sin 2\phi\right) \\
&+\sqrt{2\epsilon(1+\epsilon)}\cos\Phi\left(r^5_{11}\sin^2\theta + r^5_{00}\cos^2\theta - \sqrt{2}\Re r^5_{10}\sin 2\theta\cos\phi - r^5_{1-1}\sin^2\theta\cos 2\phi\right) \\
&+\sqrt{2\epsilon(1+\epsilon)}\sin\Phi\left(\sqrt{2}\Im r^6_{10}\sin 2\theta\sin\phi + \Im r^6_{1-1}\sin^2\theta\sin 2\phi\right) \\
&+P_b\Big[\sqrt{1-\epsilon^2}\left(\sqrt{2}\Im r^3_{10}\sin 2\theta\sin\phi + \Im r^3_{1-1}\sin^2\theta\sin 2\phi\right) \\
&+\sqrt{2\epsilon(1-\epsilon)}\cos\Phi\left(\sqrt{2}\Re r^7_{10}\sin 2\theta\sin\phi + \Im r^7_{1-1}\sin^2\theta\sin 2\phi\right) \\
&+\sqrt{2\epsilon(1-\epsilon)}\sin\Phi\times \\
&\left(r^8_{11}\sin^2\theta + r^8_{00}\cos^2\theta - \sqrt{2}\Im r^8_{10}\sin 2\theta\cos\phi - r^8_{1-1}\sin^2\theta\cos 2\phi\right)\Big]\Big).
\end{aligned}$$

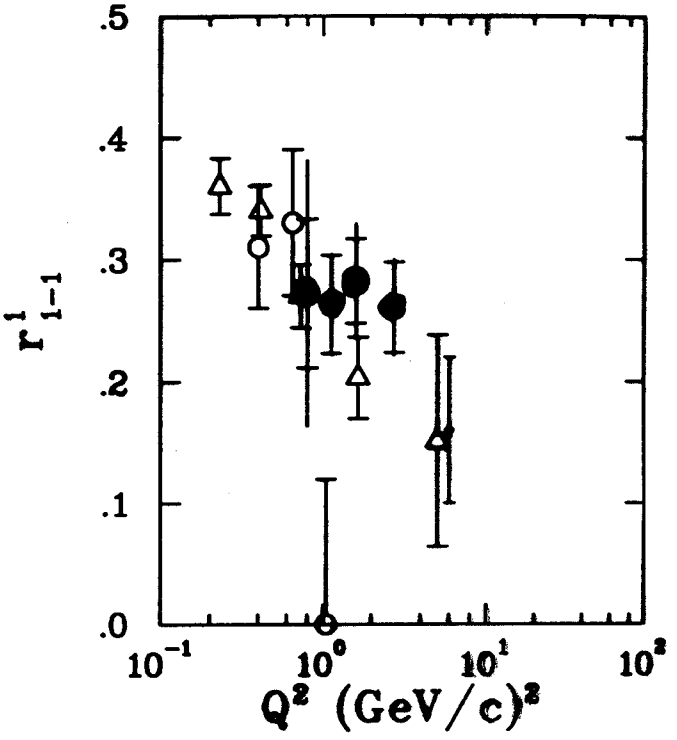
r^α_{ij} = matrix elements

ε = longitudinal polarization of photon flux

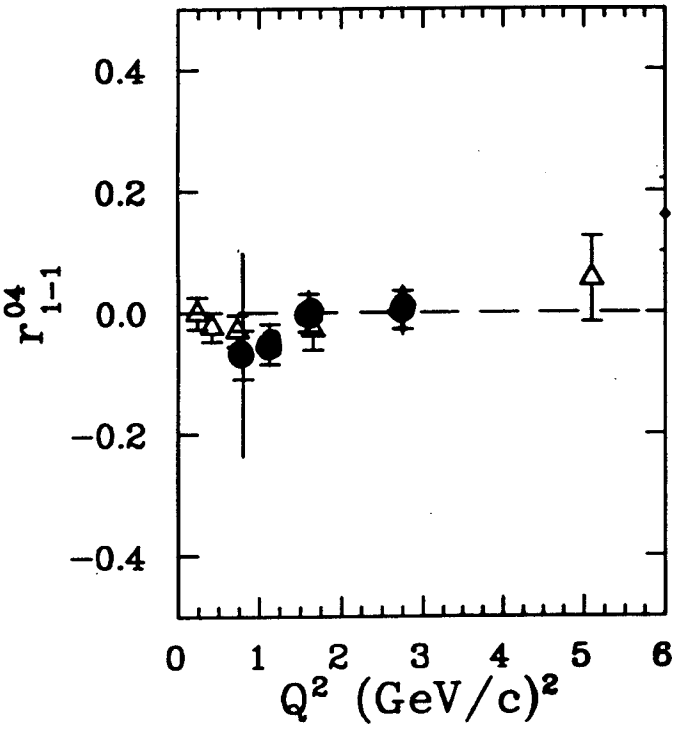
$$r^{04}_{ik} = \frac{\rho^0_{ik} + \varepsilon R \rho^4_{ik}}{1+\varepsilon R} \qquad r^\alpha_{ik} = \frac{\rho^\alpha_{ik}}{1+\varepsilon R} \qquad r^\alpha_{ik} = \frac{\sqrt{R}\,\rho^\alpha_{ik}}{1+\varepsilon R}$$

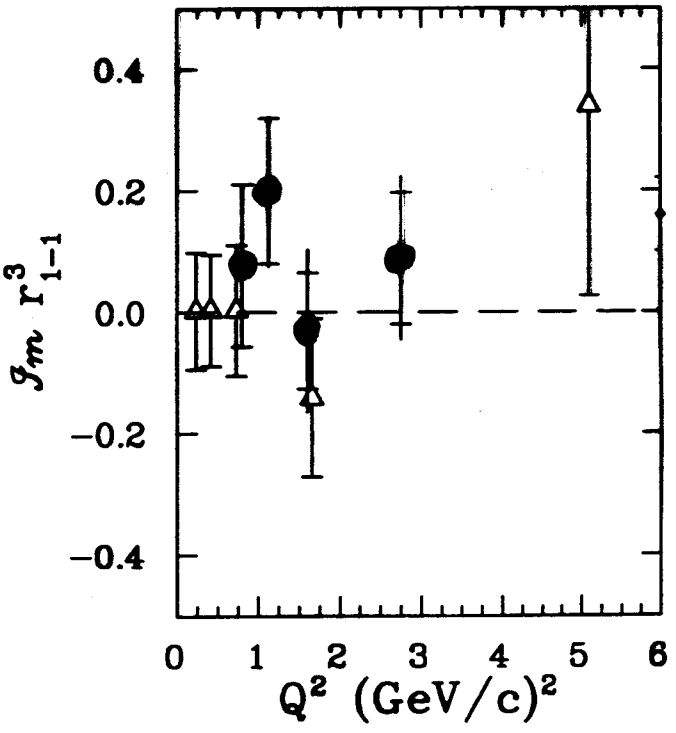


LONGITUDINAL POLARIZATION



INTERFERENCE BETWEEN LINEAR POLARIZATIONS OF γ & VM





INTERFERENCE BETWEEN SCHC & NON-SCHC AMPLITUDES

"SELLING POINTS" FOR VM PHYSICS

- HADRONIC STRUCTURE OF PHOTON
- EVOLUTION OF $q\bar{q} \rightarrow$ VM
- USE FLAVOR OF VM CONSTITUENTS TO STUDY DIFFRACTION MECHANISM
- THEORETICAL ADVANCES

  e.g., Vanderhaeghen, Guichon, Guidal

  Pichowsky & Lee

  + many others

- HELICITY AMPLITUDES PROVIDE SIGNIFICANT TESTS FOR THEORY

EXPERIMENTAL CONSIDERATIONS

- NEED A "PAIR SPECTROMETER" WITH GOOD PID

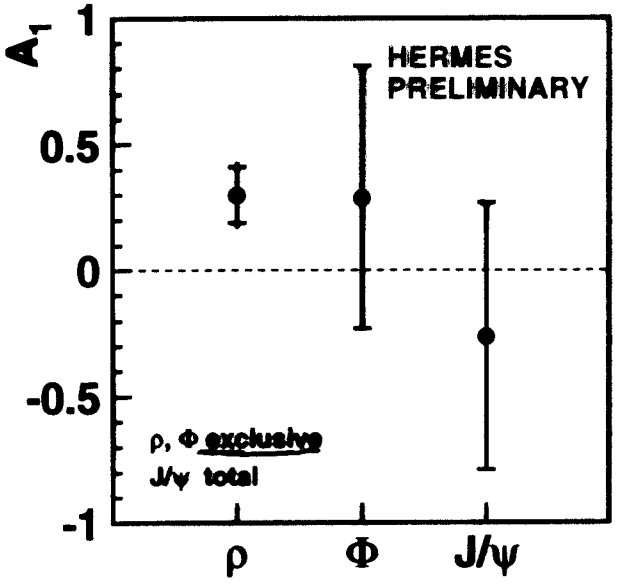
  ρ^0 LARGE OPENING ANGLES (ALSO J/ψ)

  ϕ^0 SMALL OPENING ANGLES

  open geometry? OR PART OF HALL B?

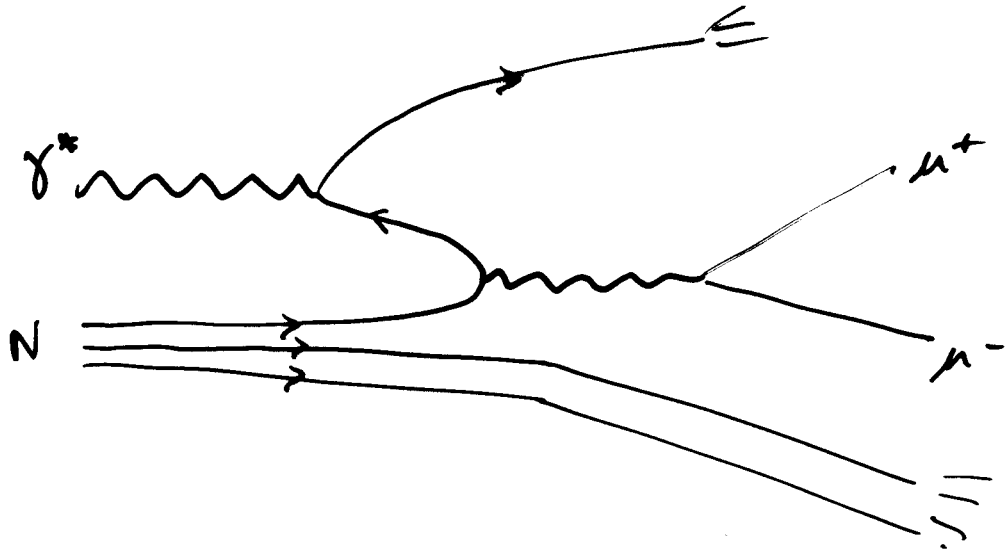
- POLARIZED BEAMS AND TARGETS ✓

DOUBLE SPIN ASYMMETRY IN VM PRODUCTION



WILD SPECULATION I

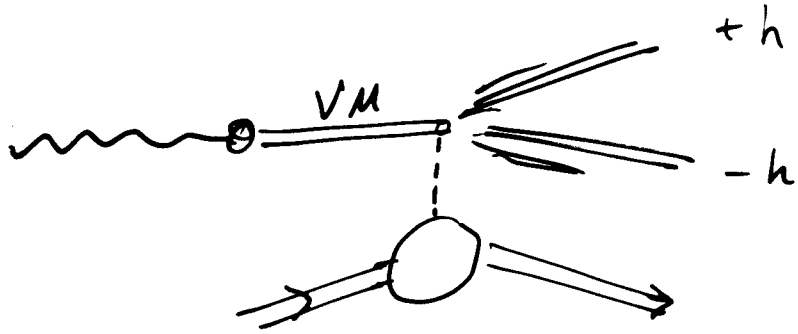
CAN WE FIND "DRELL-YAN" FROM γ's ?



IF WE DO, IS IT USEFUL ?

WILD SPECULATION II

CAN WE DIFFRACTIVELY DISSOCIATE VM's?



IF SO CAN WE LEARN ABOUT VM wavefunction?

"SUMMARY"

- IMPORTANT PROGRAMS BEING DEVELOPED
- CONSIDER MORE DIFFRACTIVE PHYSICS